

Preparing for Tomorrow's High Tide

Comment [SL1]: Title ok?

A Progress Report of the  
Delaware Sea Level Rise Advisory Committee

October 2011

(October 7 DRAFT VERSION

Incorporating written changes from committee members  
received by 10/3/11 and verbal comments from 10/4/11 SLRAC meeting)

## Introduction

Delaware is a coastal state; its economy and quality of life have historically been linked to its shoreline, its vast expanses of protected tidal wetlands and its fertile farm fields. Because of its location and dependence on the coast, Delaware is particularly vulnerable to the effects of rising sea levels.

The line between land and sea along Delaware's coast is constantly on the move. It is obvious to those who live near, or spend time on, the water that the high tide line along Delaware's shorelines fluctuates daily depending on local weather and the cycle of the moon. Less obvious is that fact that for over 10,000 years the high tide line has been slowly and steadily moving inland.

Tide data have been collected at Lewes for 90 years and at Reedy Point (located near the C&D Canal) for 50 years. These data sets have given scientists a consistent long-term data set to track tidal fluctuation and water level changes in the ocean and bays. These data show that the sea level in Delaware has risen about a foot over the last century. Other long-term tide stations within the Mid-Atlantic region show similar trends.

### <INSERT LEWES TIDE GAUGE GRAPH>

Globally, sea level rises for two main reasons: warming water and loss of ice on land. As the ocean absorbs solar radiation, the water in the ocean becomes warmer. When water warms, it expands, causing the water level to rise. In addition, as the earth becomes warmer, land-based glaciers and ice-caps melt. This melt-water increases sea levels worldwide. The worldwide average rate of sea level rise during the twentieth century was 0.07 inches per year (or 7 inches over 100 years).

In Delaware, our local sea level is rising faster than the worldwide average due to additional geologic factors, including movement of the plates that make up the earth's crust. Delaware and its surrounding states are actually slowly sinking, while land on other parts of the coast is rising. The mean sea level rise trend recorded at the tide station at Lewes is 0.13 inches per year (or 13 inches over 100 years).

Rising water levels in the oceans worldwide and sinking land locally combine to make Delaware's current rate of sea level rise almost twice the global rate of sea level rise. While it cannot be proven with absolute certainty, many scientists have predicted that the rate of sea level rise occurring today will likely become greater in the decades to come. If this happens, it will affect homes, businesses, roads, and natural areas among others. Many Federal, State and local officials have decided that it is prudent to begin planning now for the effects of rising sea levels. A survey of Delaware citizens showed that they think that government, businesses and others should be doing more to prepare for sea level rise.

### Text Box: Results of SLR Survey

**Comment [SL2]:** Suggestion to provide brief intro to SLRAC/purpose of the document at very beginning

**Comment [SL3]:** Comment to add info on importance of coast to be incorporated

**Comment [SL4]:** Paragraph reworked to include comments from several individuals.

**Comment [SL5]:** Comments to clarify this section incorporated

**Comment [SL6]:** Comments to clarify this section incorporated

**Comment [SL7]:** Commenters wanted specific rate numbers - incorporated

**Comment [SL8]:** Comments that this section were confusing, too technical and/or not necessary. Changes made

**Comment [SL9]:** Commenters wanted specific rate numbers - incorporated.

**Comment [SL10]:** Inserted clarifier about uncertainty

66% of Delawareans think that corporations and industry should be doing more to address or reduce the impacts of sea level rise.

59% of Delawareans think that state government officials should be doing more to address or reduce the impacts of sea level rise.

80% of Delawareans think that action should be taken to address or reduce the impacts of sea level rise before they occur.

DRAFT

## Future Sea Level Rise

In 2009, the Delaware Department of Natural Resources and Environmental Control (DNREC) formed a Sea Level Rise Technical Workgroup to provide planning scenarios for sea level rise up to the year 2100. This workgroup, comprised of scientists from the University of Delaware, Delaware Geological Survey, Center for the Inland Bays, Partnership for the Delaware Estuary and DNREC, reviewed historic data for local sea level rise and reviewed the findings of international and national expert panels. Based on this information, the Sea Level Rise Technical Workgroup recommended a range of possible scenarios because it is not possible to precisely predict future rates of sea level rise. These scenarios can be used for understanding and planning for future sea level rise.

Their most conservative scenario was a sea level rise of 0.5 meters (1.6 feet) between now and the year 2100. This scenario is slightly higher than the current rate of sea level rise in Delaware and is partially based on lower estimates for future global warming. Their highest scenario was a sea level rise of 1.5 meters (4.9 feet) between now and the year 2100. This scenario is based on a higher rate of sea level rise from higher estimates of future global warming. Their middle scenario was a sea level rise of 1.0 meter (3.3 feet) between now and the year 2100, and it is based on moderate estimates of future global warming. From these planning scenarios, a series of maps was developed using very accurate elevation data. These maps show the areas that could be flooded (or inundated) for each planning scenario. The inundation areas of these maps were used by the Sea Level Rise Advisory Committee to assess Delaware's vulnerability to future sea level rise. The maps are available through an on-line viewer at: <http://www.dnrec.delaware.gov/Pages/SLRMaps.aspx>

It is important to note that scientists are continually working to improve the data about sea level rise and to provide better predictions of future sea levels. As new data and information becomes available, the planning scenarios and maps will be revised and updated and the impacts can be re-evaluated.

**INSERT BOWERS MAP USED IN OUTDOOR DE MAG**

**Comment [SL11]:** Provided more info on workgroup

**Comment [SL12]:** Comment to mention the reports that were reviewed. Not yet included.

**Comment [SL13]:** Comment to include info on how climate change and sea level rise are related (yet different). Not yet included.

## Impacts of Sea Level Rise

Rising sea levels can cause several major problems: loss of low-lying land and structures; saltwater intrusion into ground water and surface water; and increased coastal flooding from storm events.

Inundation of low-lying land and structures can occur when the sea level rises faster than natural forces can build land up, or where shoreline protection structures are not built. This can cause dry land to become flooded and can cause wetlands to convert into open water. Structures, including homes, roads and utilities that have been built in low-lying areas can become difficult to access, suffer structural instability and damage or become unusable. The sea level rise inundation maps show the areas where this might occur if we do not act.

Saltwater intrusion of ground water and streams can also occur as sea levels increase. In rivers and streams, the “salt-line” will move further inland, changing the type of vegetation in and around the stream and changing fish spawning areas. It also may affect intake structures for drinking water and industry. In certain areas, water from the ocean and bay may turn groundwater supplies salty, impacting water for drinking and irrigation.

As sea level rises, flooding from coastal storm events may also cause more damage. Storm surges from nor’easters and hurricanes will move farther inland into places that are not normally flooded. This can happen due to the higher mean sea level combined with the loss of tidal wetlands that provide natural flood protection and increased coastal erosion. More frequent flooding can cut off evacuation routes and damage homes and infrastructure. While increased flooding is a very important consideration, understanding storm surge impacts statewide is a complicated undertaking and will require additional research and data collection. Because of this, the maps that the Sea Level Rise Advisory Committee are using to determine potential future effects of sea level rise are a “bathtub model”, showing all land below a certain elevation as flooded at each scenario. The maps do not yet include future storm surges, which could be higher than they have been in the past.

**Comment [SL14]:** Comment to insert graphic about SLR impacts

**Comment [SL15]:** Comments to include more explanation incorporated

**Comment [SL16]:** Comment to include the concept of bathtub models incorporated

## Importance of Planning Early for Sea Level Rise

Delawareans are always planning for the future, whether it is for retirement, a business expansion, a park, a school or a new highway. Most of these plans look forward by 20 to 30 years, but new amenities like a park or a new bridge have lifespans of 50 to 100 years. The existing rate of sea level rise is rarely considered in such plans. Accounting for changes in sea level that maybe expected to occur over the lifetime of these projects will help us make better informed decisions for public and private investments by minimizing risk, minimizing potential for damage and reducing the need for retrofits and replacement structures. For example, expensive retrofits or replacements of roads and buildings could be avoided by building a structure that is designed to withstand a certain rise in sea level. Proactive planning may also ensure that funding and resources are available for projects like shoreline stabilization, wetland restoration and infrastructure improvements that may be necessary to help Delaware's economy and natural resources continue to flourish even with the challenges of sea level rise.

Planning for the long-term effects of sea level rise may also help us be better prepared for flooding from coastal storms. Storm surges of between 2 and 4 feet frequently occur along the Delaware Bay and Atlantic coast from tropical storms and nor'easters. Delaware's largest storm on record, a nor'easter that occurred in 1962 caused a storm surge of 4.5 feet in Lewes; a nor'easter that occurred on Mother's Day in 2008 produced a storm surge of 4 feet in Bowers Beach. These storm surges are similar to our highest sea level rise planning scenarios; any actions taken to reduce the effects of sea level rise will also have the added benefit of added protection from storm surge flooding.

**Comment [SL17]:** Incorporated clarifying text

**Comment [SL18]:** Added info on lack of slr in planning today

**Comment [SL19]:** Comment as to whether this section is necessary?

## Delaware's Sea Level Rise Advisory Committee

Delaware's Sea Level Rise Advisory Committee was established to help the state plan early for the effects of future sea level rise because sea level rise could affect everything ranging from infrastructure sustainability to crop yields. The committee was established by invitation of Collin O'Mara, Secretary of the Department of Natural Resources and Environmental Control (DNREC) to investigate Delaware's vulnerability to sea level rise and to provide recommendations about how to best prepare for future sea levels. The committee is comprised of members from a wide variety of interest groups, including State agencies, local governments, citizen organizations, business organizations and environmental organizations. The committee's work has been split into two phases, a Vulnerability Assessment phase and an Adaptation Planning phase.

This document summarizes some of the major findings of the Vulnerability Assessment phase. The Sea Level Rise Advisory Committee is now beginning to investigate ways that government, businesses and citizens can modify (or adapt) their policies and business practices to reduce the impact of sea level rise to our state's citizens, economy and natural resources. The final report of the Sea Level Rise Advisory Committee will contain information and recommendations that will help governments, businesses and citizens prepare for future sea levels.

It is the intent of the Sea Level Rise Advisory Committee to provide information and guidance to help people make informed decisions when considering activities and investments in areas that may be at risk from the effects of future sea level rise. The Advisory Committee will not oversee implementation of protective measures. Any action that would require a change in legislation or regulations will go through the normal legislative and public processes before it can be enacted.

**INSERT TEXT BOX SLRAC Members**

**INSERT TEXT BOX committee goal statement**

**The goal of the Sea Level Rise Advisory Committee is to assess Delaware's vulnerability to current and future inundation problems that may be exacerbated by sea level rise and to develop a set of recommendations for state agencies, local governments, businesses and citizens to enable them to adapt programs, policies, business practices and make informed decisions.**

**Comment [SL20]:** Comment to specify DNREC and executive agencies and/or policy makers. Included target audience from goal statement.

## Delaware's Vulnerability to Sea Level Rise

**Comment [SL21]:** Minor editorial corrections in this section

Many people are surprised to find out that sea level rise effects may be seen throughout each of Delaware's three counties, not only the ocean beach communities. In fact, some of our most vulnerable areas are located in Kent and New Castle Counties. In Kent County, vast stretches of protected tidal marshes that are home to a wide array of wildlife species are at particular risk from increasing sea levels, but fewer homes and businesses are impacted because coastal Kent County remains relatively rural. In New Castle County, developed areas like Delaware City, the Town of New Castle and low-lying areas in Wilmington are at risk, as are job centers like the Port of Wilmington and Wilmington's Riverfront. In Sussex County, developed areas along the Delaware Bay and Inland Bays are at risk, as are developed areas on the barrier island between Dewey Beach and Fenwick Island.

The Sea Level Rise Advisory Committee formed three workgroups to investigate potential impacts of sea level rise. The workgroups were Natural Resources, Public Safety & Infrastructure, and Society & Economy. Each workgroup used existing data and the sea level rise inundation maps to determine what important resources, amenities and structures were within areas that might become inundated as a result of sea level rise. They also documented potential effects to Delaware's residents, economy, and natural resources.

### Natural Resources

The Natural Resources Workgroup focused its work on assessing impacts that might occur in Delaware's important wildlife habitats, preserved land, nature preserves and agricultural areas. The workgroup's major findings include

- Sea level rise is predicted to affect up to 99% of Delaware's tidal wetlands. These wetlands protect communities from floods and storms and serve as critical habitat for fish, shellfish, birds, waterfowl and wetland plants. If tidal wetlands are not able to move landward or accumulate sediment to keep pace with rising waters, these areas will revert to open water. The inundation of tidal wetlands will create major environmental changes including increased storm surge susceptibility, fewer fish and poorer water quality in our bays and beaches.
- The number and variety of species present, or biodiversity, within Delaware may be negatively affected as different habitat types are impaired or eliminated by rising water. Some unique environments, such as freshwater tidal wetlands, are becoming increasingly uncommon not only in Delaware but in the Mid-Atlantic and globally. Sea level rise will further stress these distinctive environments and the plant and animal species that inhabit them.
- The beaches along the Atlantic Coast and Delaware Bay provide recreational opportunities, bring in tourism dollars, provide storm surge protection for coastal communities and are important habitat for key species like horseshoe crabs and migrating shorebirds. Beach replenishment activities offer short term protection from rising waters but the cost



effectiveness and sustainability of these efforts are often debated. An increased rate of sea level rise may make it more difficult and costly to maintain beaches

- Agriculture is integral not only to Delaware's economy, but to the social, environmental and cultural heritage of our state. Impacts from sea level rise (and associated effects from salt water) include decreased crop yield, inability to grow salt-intolerant crops, and impacts to the health of domestic livestock. Additionally, shallow irrigation wells in coastal areas may become contaminated with salt water.
- Protected lands in coastal areas, such as State forests and wildlife areas, federal wildlife refuges, parks, conservation lands and nature preserves, will be inundated by sea level rise. Statewide, a large percentage (*44% statewide under the highest scenario*) of protected lands may be affected. Impacts to these areas will include reduced recreational opportunities such as hunting, fishing, and bird watching, and loss of wildlife habitat and open space.

**Text Box: Workgroup members**

Partnership for the Delaware Estuary  
The Nature Conservancy  
Center for the Inland Bays  
Department of Natural Resources and Environmental Control  
Department of Agriculture  
Delaware Nature Society  
Delaware Farm Bureau  
Coastal Delaware National Wildlife Refuge Complex

**Text Box: Resources Analyzed**

Highly Productive Soils  
Agricultural Land Preservation Districts  
Agricultural Conservation Easements  
Protected Lands  
Undeveloped Groundwater Recharge Areas  
Tidal Wetlands  
Non-Tidal Wetlands  
Impoundments  
Habitats of Conservation Concern  
Shellfish Areas  
Upland Forest  
Natural Heritage Program Native Vegetation

## Society and Economy

The Society and Economy Workgroup focused its work on assessing impacts from rising seas that might be felt by citizens, businesses, agriculture and vulnerable populations. Additional studies and research will be necessary to fully understand and quantify the economic and social impacts of sea level rise.

Some of the workgroup's major findings include:

- Thousands of homes throughout Delaware are within areas that could be flooded as sea levels rise. Although the total percentage of homes potentially inundated is low (5% under the highest case scenario), the impact to individual families and communities from repetitive flooding and loss of homes could be significant. The most vulnerable homes are within low-lying areas along the Delaware River and Bay, and around the Inland Bays. Mobile home communities in Sussex County are particularly at risk; over 30% of the county's trailer homes are potentially inundated under the highest case scenario.
- A small percentage (5% under the highest case scenario) of Delaware's commercial properties are within areas that could be flooded as sea levels rise, the majority of which are located in low-lying areas in Sussex County. For many businesses, this may mean a reduction in accessibility to customers and added expenses for flood protection and damage repairs. Commercial and recreational fishing operations and water-based tourism businesses will be particularly affected, as they are located in waterfront areas by necessity.
- A small percentage (8% at the highest case scenario) of Delaware's industrial and manufacturing facilities will be directly flooded by rising sea levels, but the operations of many other facilities may be affected by the impact of rising water on their associated structures including wastewater treatment ponds, intake pipes and docks. These facilities are important not just for providing goods and materials to the region, but for providing jobs for Delawareans and tax revenues for state and local governments. Increased flooding events at these facilities may lead to costly repairs and upgrades, loss of production or eventual abandonment of the site.
- A small percentage of Delaware's agricultural land (4% at the highest case scenario) would be inundated by rising sea levels, resulting in the loss of their use for crop production. Farmers in surrounding areas may also have difficulty continuing farming operations or suffer reduced crop yields due to saltwater intrusion into irrigation water or increased flooding events from storm surges.
- A small percentage (4% at the highest case scenario) of archeological and historical sites catalogued by the Delaware State Historic Preservation Office would be permanently flooded by future sea levels. Rising water tables damage archeological sites well before they are lost to permanent flooding; both will result in the irrecoverable loss of information important to understanding Delaware's past.

**Comment [SL22]:** Comment re adding other impacts to fisherman like fish/shellfish habitat. Comment not incorporated – these impacts addressed in natural resources. Relationship between all of these factors a bit too complex to describe well in this report.

**Comment [SL23]:** Comment to mention conversion to wetlands - not incorporated, too complex

- **Outdoor** recreational opportunities will be significantly impacted by rising sea levels. As an example, 17% of recreational parkland statewide would be permanently flooded by future sea levels under the lowest scenario; 25% at the highest scenario. 33% of boat ramps in the state are located within areas likely to be permanently flooded under the lowest scenario; 48% at the highest scenario. Flooding of these facilities will result in fewer outdoor recreational opportunities for citizens, loss of coastal access points and potential loss of tourism revenue.

**Comment [SL24]:** Comment requesting info on how much beach area would be lost. This data is not available.

#### **Text Box: Resources Analyzed**

Commercial Addresses  
Business Licenses  
Facilities permitted under the Coastal Zone Act  
Toxic Release Inventory Sites  
Residential Addresses  
Future Development Areas  
Acreage of Actively Farmed Lands  
Acreage of Confined Feeding Operations (CAFO)  
Acreages of Farmsteads and Related Buildings  
US Census  
Active Recreational Areas  
Open Space Areas  
Boat Ramps  
State Historic Sites  
National Register Sites

#### **Text Box: Workgroup agencies**

Delaware Department of Natural Resources and Environmental Control  
Delaware Department of Health and Social Services  
Delaware Economic Development Office  
Delaware Association of Realtors  
University of Delaware  
Delaware Department of Agriculture  
Delaware Office of Management and Budget  
Delaware Chamber of Commerce  
Delaware House of Representatives  
New Castle County  
Delaware Homebuilders Association  
Kent County  
Delaware Department of Transportation  
Delaware Insurance Commissioner's Office  
Positive Growth Alliance

## Public Safety and Infrastructure

The Public Safety and Infrastructure Workgroup focused its work on assessing impacts that might be felt by public safety providers, transportation, utilities, public services, and industrial services. The workgroup gathered data from a wide range of sources to assess the impacts sea level rise will have on Delaware's infrastructure. Some of the workgroup's major findings include:

- A small percentage of ambulance/paramedic stations (9% under the highest case scenario) and fire and rescue stations (9% under the highest case scenario) would be flooded by future levels of sea level rise. While the physical number of stations impacted is small statewide, citizens living within their service areas would be significantly impacted by a reduction in service and/or longer travel times. .
- A moderate percentage of police stations (12% under the highest case scenario) would be flooded by future sea level rise. While the number of stations impacted is relatively small, citizens living within their service areas would likely experience increased response times if these stations were not able to continue functioning.
- Statewide, a small percentage (5% under the highest case scenario) of the total road mileage in the state would be flooded. Some of these roadways are already chronically flooded during storm events and extreme high tides. Some of these roads are important evacuation routes like Route 13, Route 9 and Route 1. Flooding of even a small segment of a roadway can cause detours and increase congestion problems miles from the flooded area.
- A system of dams, dikes, and levees provide flood protection for roads, homes, businesses and wildlife areas throughout the state. Several important dikes that protect developed areas from tidal flooding are in poor condition as a result of erosion, animal burrows and overgrowth. Over half of the dams, dikes and levees Delaware would be overtopped using the medium sea level rise scenario; over 75% would be overtopped using the highest case scenario.
- A moderate percentage of waste-water treatment facilities would be affected by rising sea levels (13% at the highest case scenario). Impacts could include sewer line overflows and backups into homes, damage to structures, reduced treatment capacity, and increased operating costs.
- The Port of Wilmington, a major economic and transportation hub in Delaware, will be significantly impacted by future sea levels. Under even the lowest scenario for future sea level rise, over 30% of its docks, cargo transfer areas and warehouses would be inundated. Transport of cargo from the Port will also be affected by inundation of several local roads which connect the port to interstate highways. Without action, these impacts could mean reduction in port traffic and cargo, along with reductions to the job force and the overall economy of the region.

**Comment [SL25]:** Comment to strike mention that the dikes have not been well maintained incorporated

**Comment [SL26]:** Comment to prioritize sewer backups incorporated

**Comment [SL27]:** Comment to include damage to structure

**Comment [SL28]:** Comment to include info on connected roads incorporated.

**Text Box: Resources Analyzed**

Ambulance & Paramedic Stations  
Fire & Rescue Stations  
Police Stations  
Dams, Dikes, Levees and Tide Gates  
Public Safety Access Points  
Evacuation Routes & Emergency Shelters  
Emergency Operations Centers  
Airports & Railroads  
Roads & Bridges  
Bus Routes and Bus Stops  
DelDOT Maintenance Yards  
Aids to Navigation  
Port of Wilmington  
Cell Towers  
Electric Generation and Distribution Sites  
Underground Utilities  
Septic Tanks  
Telephone switching stations  
Waste Water facilities  
Wells  
Adult & Child Care Facilities  
Correctional facilities  
Cemeteries  
Hospitals  
Government Buildings  
Schools  
Brownfields  
Hazardous Waste Generators  
Landfills  
Manufacturing Sites  
Salvage Yards  
Contaminated Sites  
Underground Storage Tanks

**Text Box: Workgroup Agencies**

Delaware Department of Homeland Security  
Delaware Department of Transportation  
Delaware Department of Natural Resources and Environmental Control  
Delaware League of Women Voters  
Tidewater Utilities  
City of Lewes  
University of Delaware

## Next Steps

The Sea Level Rise Advisory Committee will be sharing the preliminary results of the vulnerability assessment at a series of public engagement sessions in the late fall of 2011. Information from the public will be collected and incorporated into the vulnerability assessment before it is finalized.

The vulnerability assessment will then be used by the Sea Level Rise Advisory Committee to develop guidance and in some cases recommendations for adapting to the changes that future sea levels might bring to the coastline of Delaware. The results of this study can be used for a variety of purposes: State and local agencies may use the results of this project to do more detailed studies of their assets and operations and develop detailed adaptation plans; businesses may use the results of this project to plan for future changes to their operations and customer-base and individuals may use the results of this project to plan for improvements to their homes and communities.

**Comment [SL29]:** Comment to include specific uses incorporated.

## For More Information

More information about this and other sea level rise initiatives are available online:

<http://www.dnrec.delaware.gov/coastal/Pages/SeaLevelRiseAdaptation.aspx>

## Glossary:

Adaptation –

Sea Level Rise – The rise in mean sea level (averaged over tides, seasons and weather conditions) relative to the shore nearby. Sea level rise does not include the effects of winds, waves, barometric pressure or storm surges.

Vulnerability –

Inundation

Storm Surge

**Comment [SL30]:** Tectonic subsidence removed from text and glossary